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Heavy element abundances in cool dwarf stars: An implication for the evolution of the Galaxy

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Abstract

We present revised strontium, barium and europium abundances for 63 cool stars with metallicities [Fe/H] ranging from -2.20 to 0.25. The stellar sample has been extracted from Fuhrmann's lists (1998, 2001). It is confined to main-sequence and turnoff stars. The results are based on NLTE line formation obtained in differential model atmosphere analyses of spectra that have a typical S/N of 200 and a resolution of 40000 to 60000. The element abundance ratios reveal a distinct chemical history of the halo and thick disk compared with that of the thin disk. Europium is overabundant relative to iron and barium in halo and thick disk stars suggesting that during the formation of these galactic populations high-mass stars exploding as SNe II dominated nucleosynthesis on a short time scale of the order of 1 Gyr. We note the importance of [Eu/Mg] determinations for halo stars. Our analysis leads to the preliminary conclusion that Eu/Mg ratios found in halo stars do not support current theoretical models of the r-process based on low-mass SNe; instead they seem to point at a halo formation time much shorter than 1 Gyr. A steep decline of [Eu/Fe] and a slight decline of [Eu/Ba] with increasing metallicity have been first obtained for thick disk stars. This indicates the start of nucleosynthesis in the lower mass stars, in SN I and AGB stars, which enriched the interstellar gas with iron and the most abundant s-process elements. From a decrease of the Eu/Ba ratio by ~0.100.15 dex the time interval corresponding to the thick disk formation phase can be estimated. The step-like change of element abundance ratios at the thick to thin disk transition found in our previous analysis (Mashonkina & Gehren 2000) is confirmed in this study: [Eu/Ba] and [Eu/Fe] are reduced by ~0.25 dex and ~0.15 dex, respectively; [Ba/Fe] increases by ~0.1 dex. This is indicative of an intermediate phase before the early stage of the thin disk developed, during which only evolved middle and low mass (<8 M⊙) stars contributed to nucleosynthesis. Our data provide an independent method to calculate the duration of this phase. The main s-process becomes dominant in the production of heavy elements beyond the iron group during the thin disk evolution. We find that in the thin disk stars Ba/Fe ratios increase with time from [Ba/Fe] = -0.06 in stars older than 8 Gyr to [Ba/Fe] = 0.06 in stars that are between 2 and 4 Gyr old.

Keywords

Galaxy: evolution, Line: formation, Nuclear reactions, nucleosynthesis, abundances, Stars: abundances, Stars: late-type